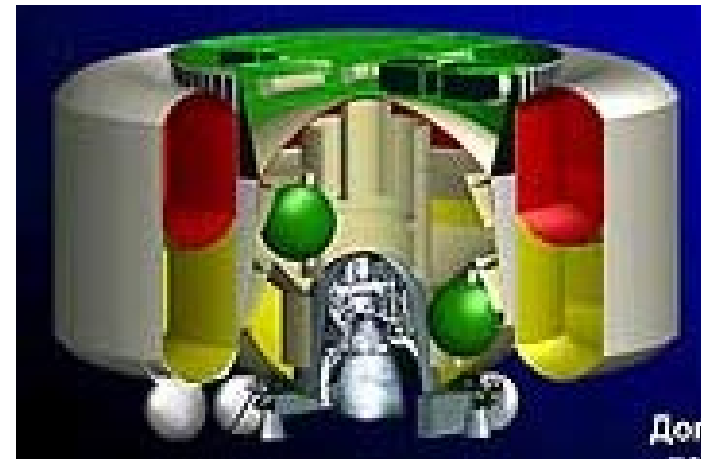
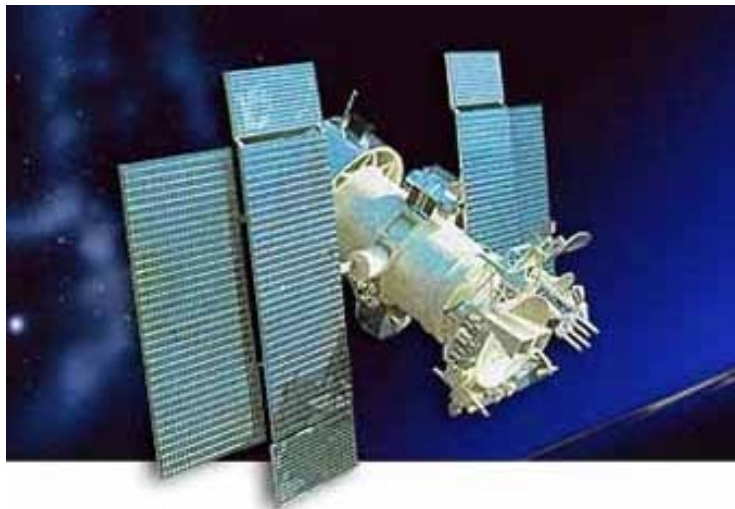




The Launch of Gorizont 45 on the First Proton K /Breeze M

Fred D. Rosenberg, Ph.D.
MIT Lincoln Laboratory

Space Control Conference
3 April 2001

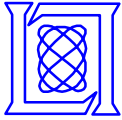


This work is sponsored by the Air Force under Air Force Contract F19628-00-C-0002 "Opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the United States Air Force."



Outline

- **Introduction**
- **Breeze M**
- **Launch Scenarios and Pre-Launch Planning**
- **Mission Events**
- **Summary**



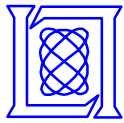
Introduction

- **On 6 June 2000 Russia launched Gorizont 45 using the newly developed Breeze M upper stage**
- **First non-historic deep space Russian launch in many years**
- **However, International Launch Services published detailed description of the booster capabilities and launch scenarios**
- **Pre-mission planning led to successful coverage of the rocket body and payload up to synchronous injection**

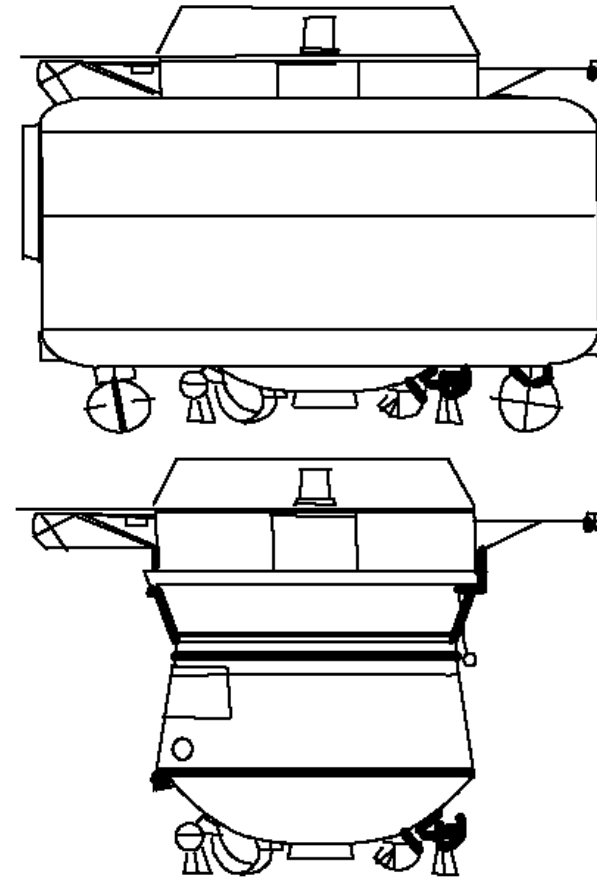
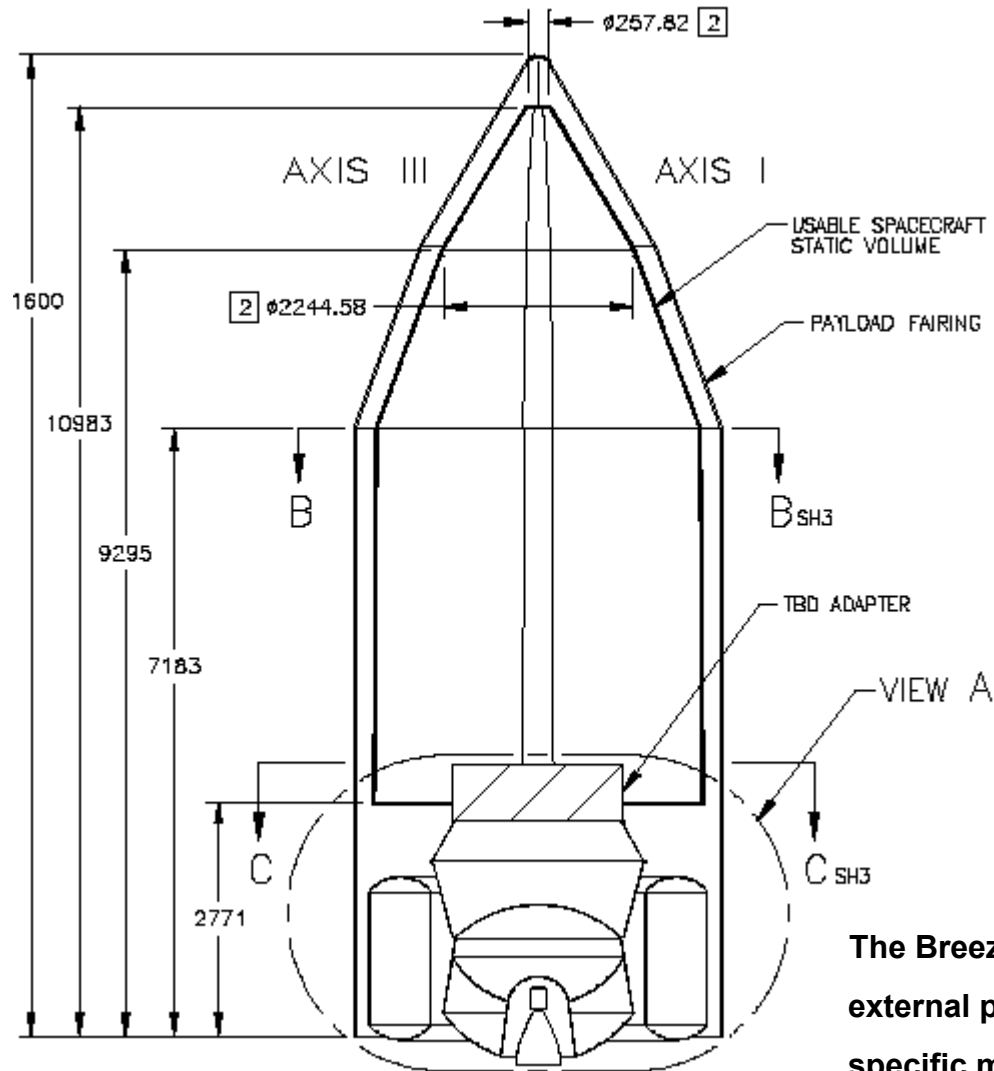


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Breeze M with Auxiliary Propulsion Tank

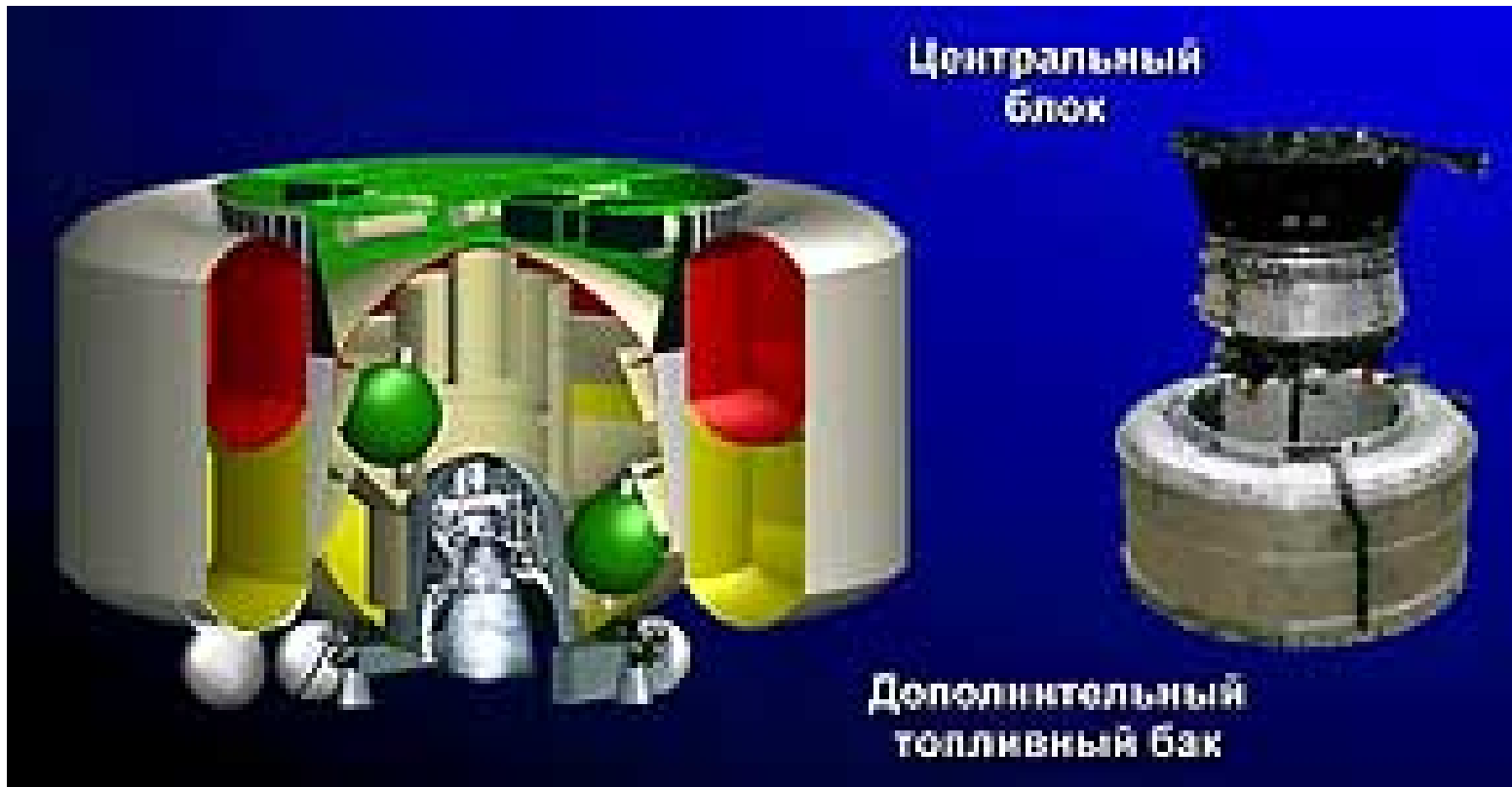


The Breeze M is comprised of a central cylinder and a jettisonable external propellant tank. Propellant carried is dependent on the specific mission requirements and is varied to maximize performance for the mission. Ref: ILSLaunch.com



Breeze M

Rocket Body and Surrounding External Fuel Tank

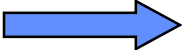


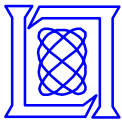
The Breeze M will be replacing the Block DM

- More lift capability
- Flexible launch profile
- 3rd stage not left in parking orbit

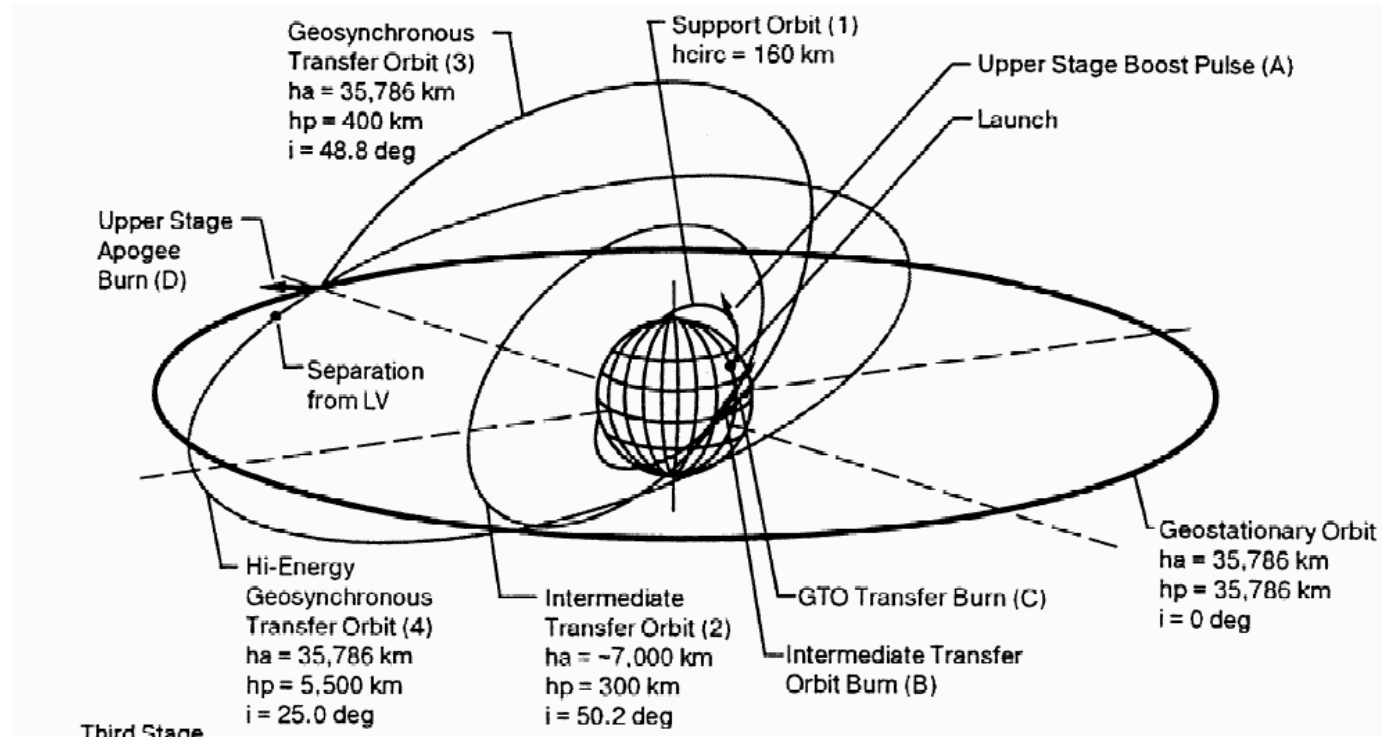


Outline

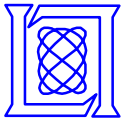
- Introduction
- Breeze M
-  • **Launch Scenarios and Pre-Launch Planning**
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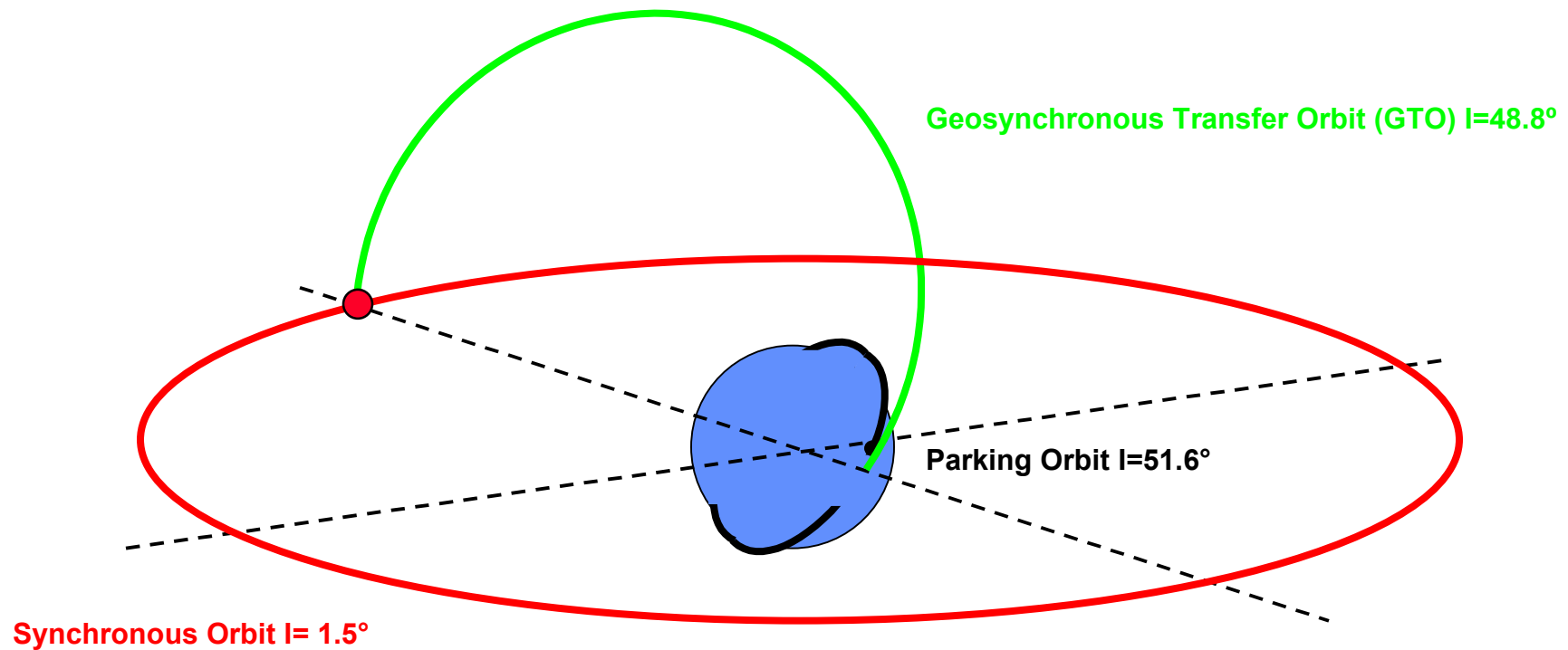
“Typical Breeze M Flight Profile to Geosynchronous Transfer Orbit”



“For typical Proton M/Breeze M missions, the first three stages inject the elements above the third stage into a sub-orbital ballistic trajectory. Approximately 2 minutes after separation, the Breeze M fourth stage performs a main engine burn to reach a low earth “support” orbit inclined 51.6 degrees to the equator. The second burn of the Breeze M engine occurs approximately 55 minutes after lift-off as the vehicle crosses the first ascending node, and lasts nearly 12 minutes. After one revolution in an intermediate transfer orbit, a third Breeze M burn occurs to complete the raising of apogee to geosynchronous altitude. The fourth Breeze M burn, which places the spacecraft into its final orbit, occurs approximately 5.5 hours later at geosynchronous altitude, and lasts ten minutes. Total launch mission duration is approximately 10 hours.”

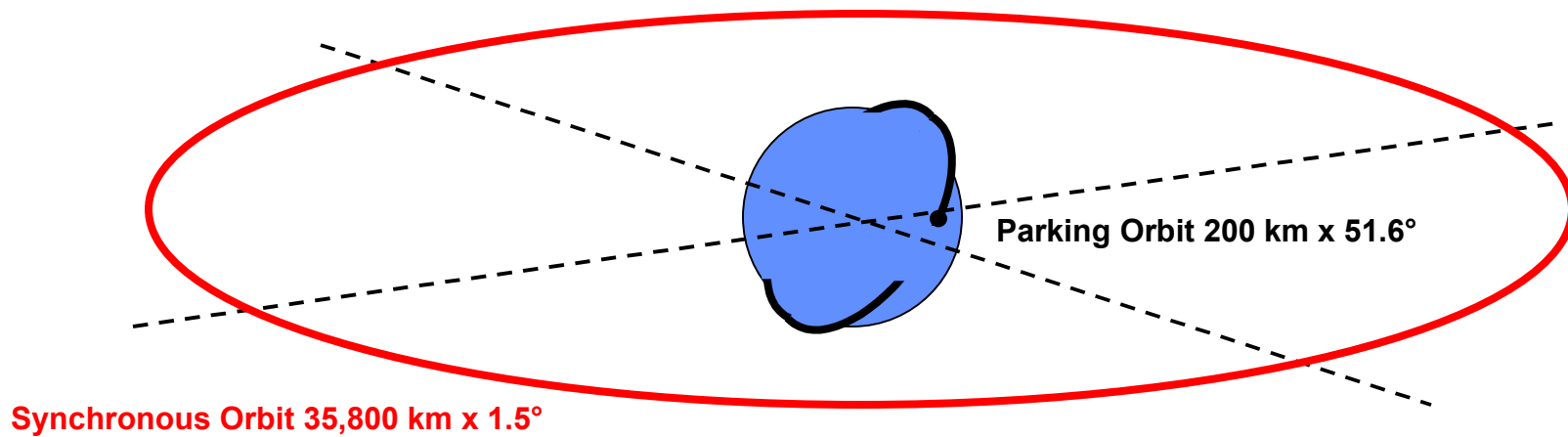


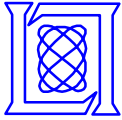
Typical Launch Scenario Using the Block DM



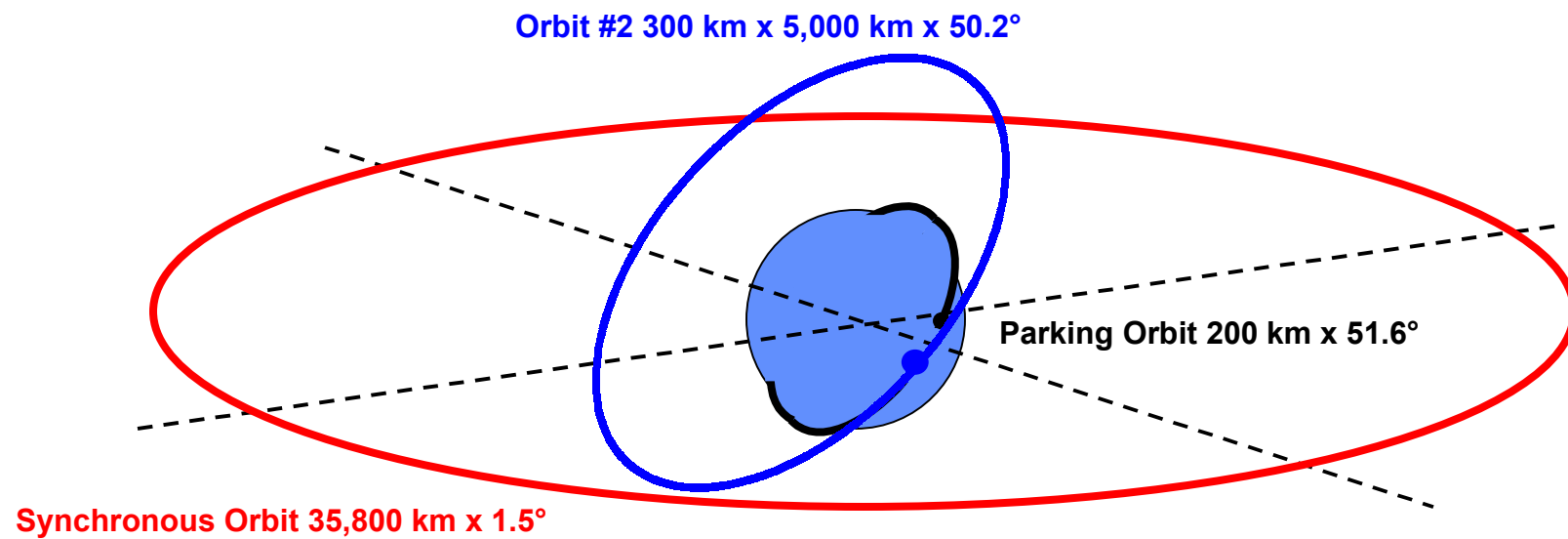


Gorizont 45 Launch Scenario



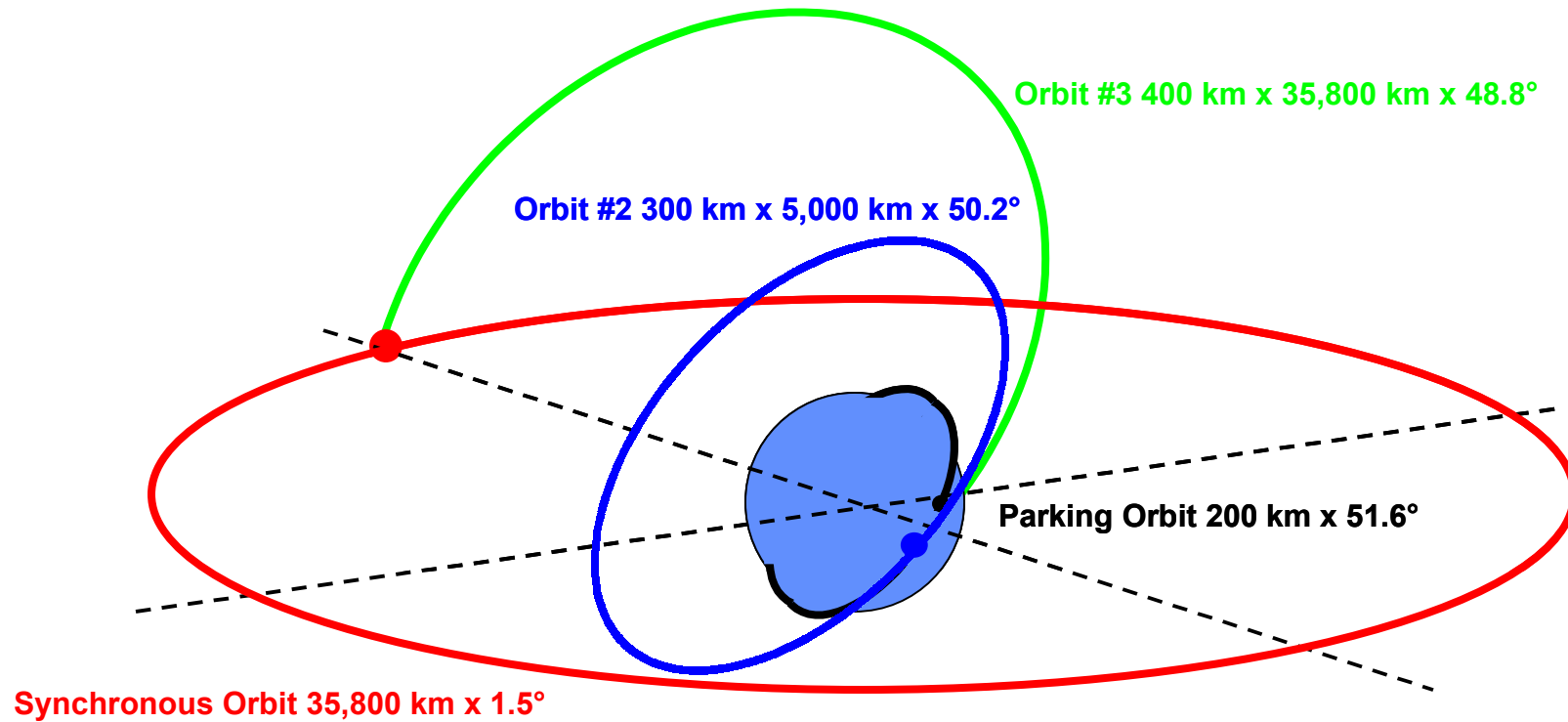


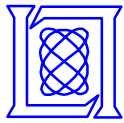
Gorizont 45 Launch Scenario



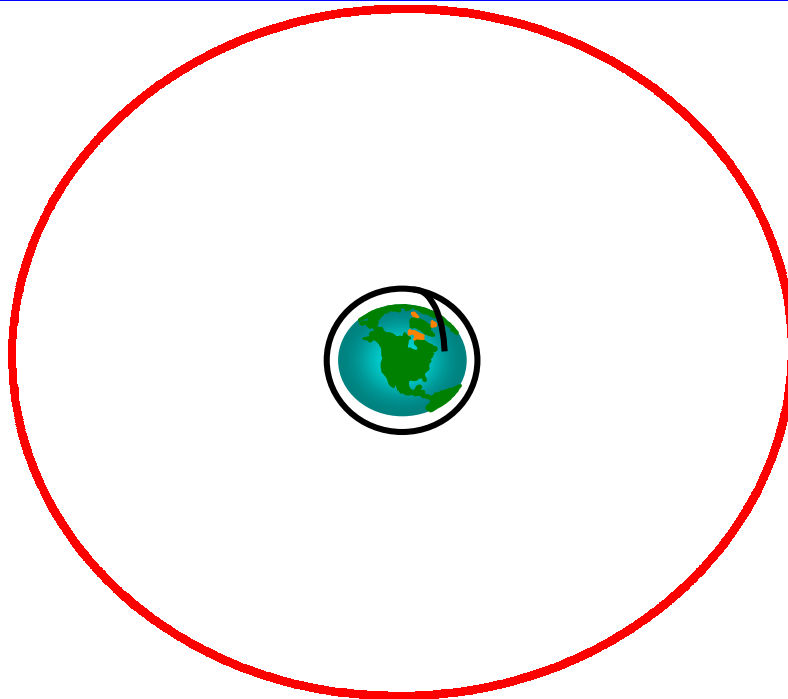


Gorizont 45 Launch Scenario





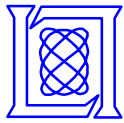
Breeze M Scenario to Geo-Synchronous Orbit



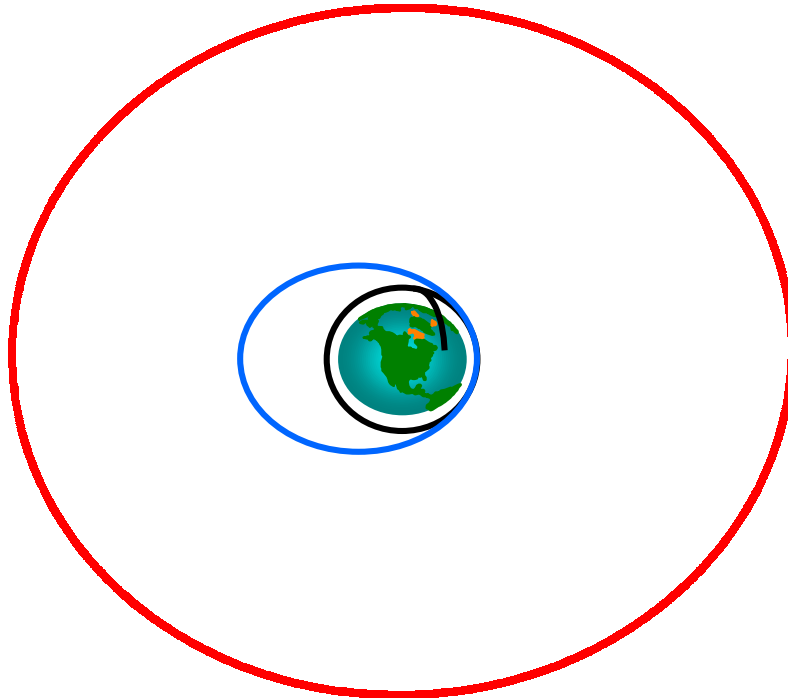
Parking Orbit 200 km x 51.6°

Synchronous Orbit 35,800 km x 0.8°

- Breeze M scenario uses multiple transfer orbits
 - lower thrust 4th stage cannot insert directly into GTO
- Inclination changes selected to minimize Δ velocity requirement
 - Δ velocity same as for Proton/Block DM scenario
- Intermediate transfer orbit apogee height dependent upon payload mass



Breeze M Scenario to Geo-Synchronous Orbit

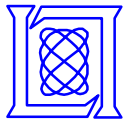


Parking Orbit 200 km x 51.6°

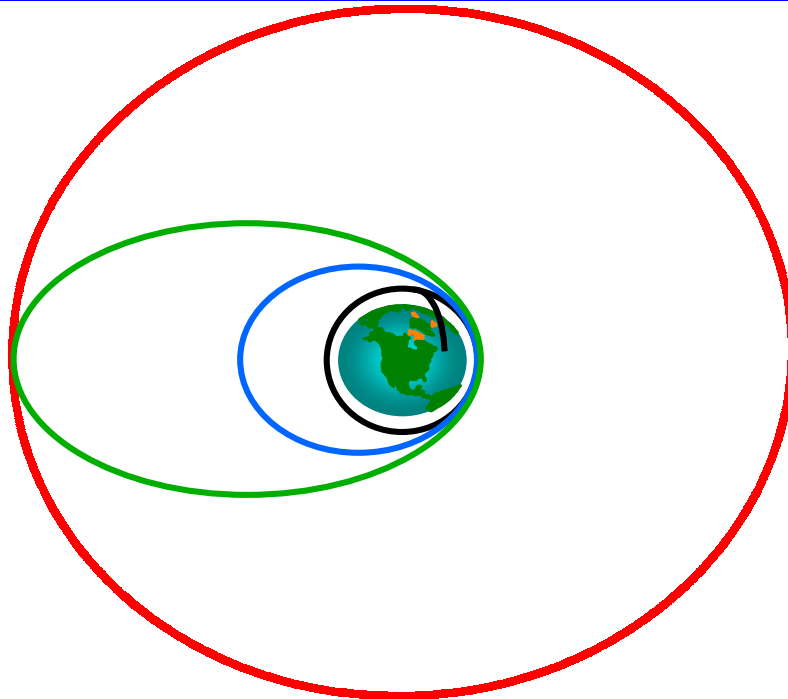
Intermediate Orbit 300 km x 5,000 km x 50.2°

Synchronous Orbit 35,800 km x 0.8°

- **Breeze M scenario uses multiple transfer orbits**
 - lower thrust 4th stage cannot insert directly into GTO
- **Inclination changes selected to minimize Δ velocity requirement**
 - Δ velocity same as for Proton/Block DM scenario
- **Intermediate transfer orbit apogee height dependent upon payload mass**



Breeze M Scenario to Geo-Synchronous Orbit



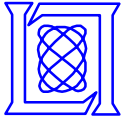
Parking Orbit 200 km x 51.6°

Intermediate Orbit 300 km x 5,000 km x 50.2°

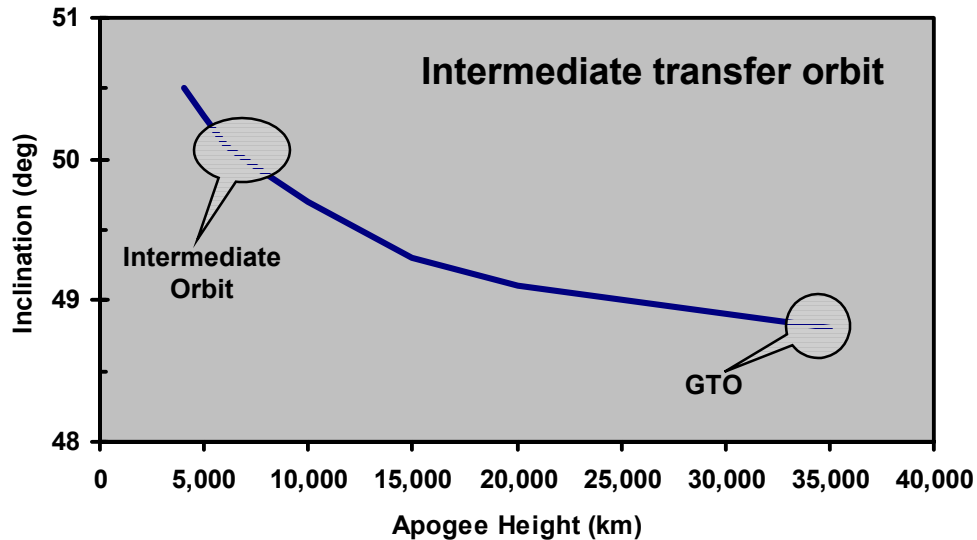
Transfer Orbit 400 km x 35,800 km x 48.8°

Synchronous Orbit 35,800 km x 0.8°

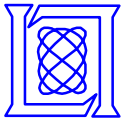
- **Breeze M scenario uses multiple transfer orbits**
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- **Intermediate transfer orbit apogee height dependent upon payload mass**



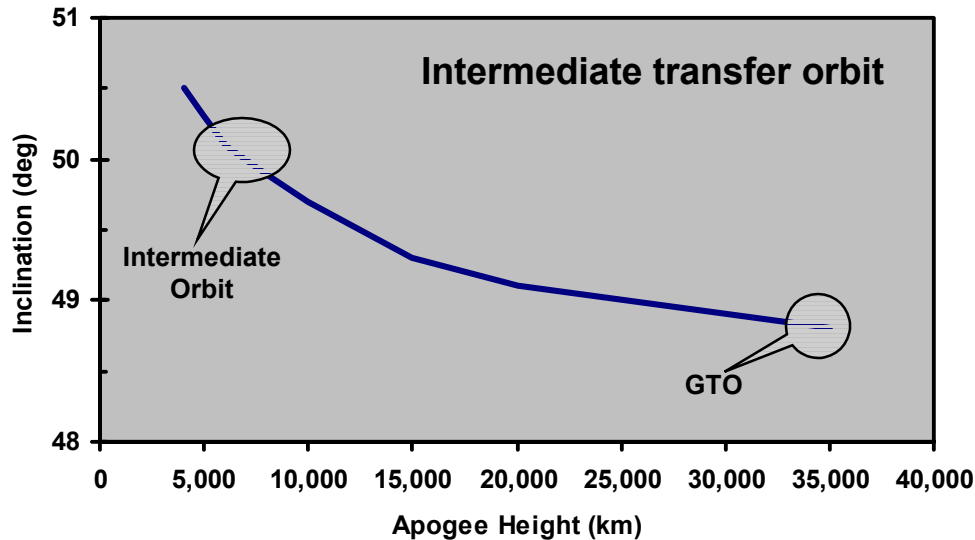
Apogee Height – Inclination Relationship



- A two-dimensional apogee height-inclination search of the intermediate transfer orbit would be very stressing
- However we can use a simple impulse burn model to limit the search to one-dimension

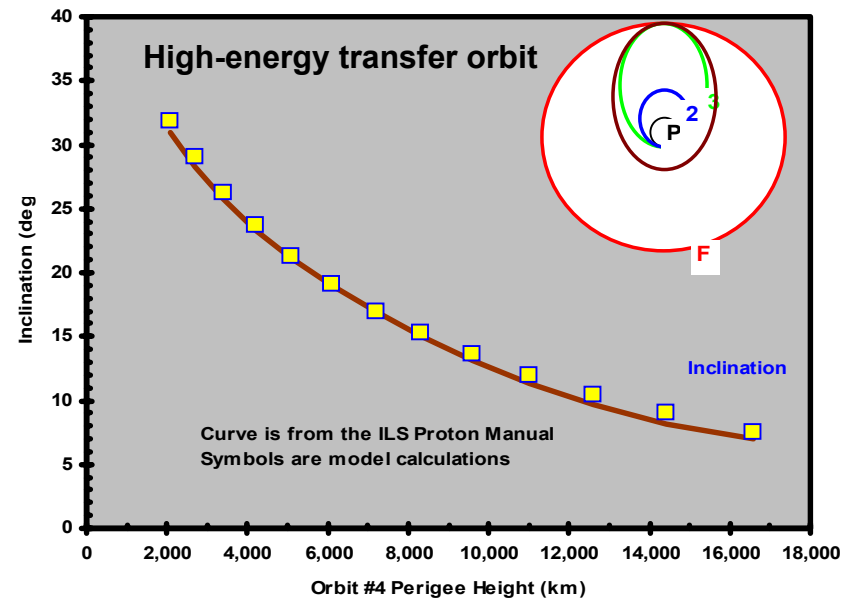


Apogee Height – Inclination Relationship



- This model has been tested against the Block DM scenario, as well as for the “high-energy transfer orbit” scenario published in the ILS Proton Manual.

- A two-dimensional apogee height-inclination search of the intermediate transfer orbit would be very stressing
- However we can use a simple impulse burn model to limit the search to one-dimension



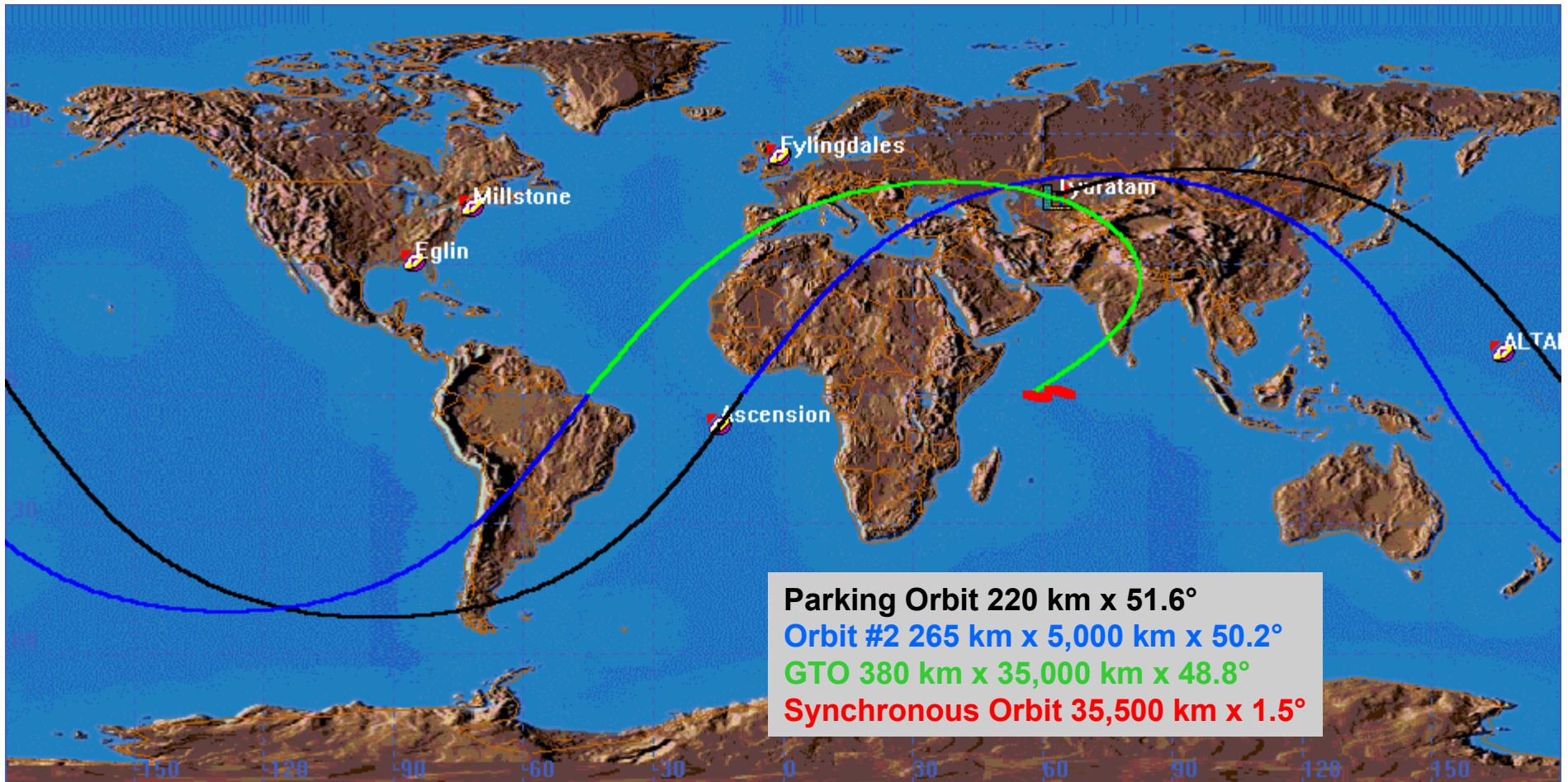


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Gorizont 45 Launch Scenario





Gorizont 45 Chronology

Parking Orbit 220 km X 51.6°

02:59 Launch
Tasked Gorizont folder by SCC
03:36 **ALTAIR** elset 95099
piece count of 1
Ascension acquisition/elset?

Intermediate Transfer Orbit 265 X 5,000 km X 50.2°

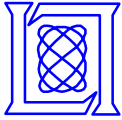
04:11 Ascending node injection into transfer orbit
04:45 **Fylingsdale** elset 90042 (acquisition from ???)
05:17 **ALTAIR** elset 95101; acquisition from FYL elset
06:00 *Faxed launch memo and briefing to SCC*

Geo Transfer Orbit 380 X 35,000 km X 48.8°

06:37 Perigee, ascending node injection into GTO
Fylingsdale track to SCC
09:09 SCC elset from Fylingdale data

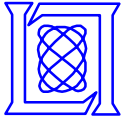
GEO drift orbit 56° drifting 10°/day toward 145°

11:48 Apogee, descending node injection into GEO drift orbit
17:04 **ALTAIR** elset on tank in GTO
17:32 **MHR** elset on tank in GTO
ALTAIR acquired payload based upon postulated drift
elset



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Summary

- **Successful coverage of non-historic launch**
 - Public information on the Web
 - Pre-mission planning at Millstone
 - SSN coordination through the SCC
 - Excellent sensor performance, particularly Fylingsdale
- **Future success depends upon**
 - Same attributes that lead to previous success
 - Use of optical and passive sensors if possible